Introduction to Software Engineering - TIE-02306

SPECIFICATION

For the public transportation data software City of Tambester's Tram network

Group 9

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VERSION HISTORY

- Ver 0.1: Document creation and outline / Duy Anh / Sept. 30
- Ver 0.2: Content and purpose of this document / Duy Anh / Oct. 2
- Ver 0.3: Product, scope, environment, and a diagram about the product/ Minh Quoc / Oct. 5
- Ver 0.3.1: Minor fix section 1.2 / Minh Quoc / Oct. 6
- Ver 0.4: Scope and Operating environment / Minh Quoc & Duy Anh / Oct. 7
- Ver 0.4.1: Some additional information to section 1.2 / Minh Quoc / Oct. 7
- Ver 0.5: Current situation, documentations, and similar products / Duy Anh / Oct. 8
- Ver 0.6: PESTE analysis added / Whole group / Oct. 8
- Ver 0.7: Stakeholder analysis added / Whole group / Oct. 9
- Ver 0.7: Minor fix some stakeholders' details / Jovana / Oct. 9
- Ver 0.8: Preliminary requirements and their categories / Whole group / Oct. 10
- Ver 0.9: Methods and timetable for requirements gathering plan / Jovana / Oct. 12
- Ver 0.9.1: User and purpose of use, preparing for finalizing 1st phase / Minh Quoc / Oct. 12
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- Ver 1.1: Use case diagram added / Jovana / Nov. 8
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- Ver 1.3.1: Description of two use cases / Jovana / Nov. 12
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- Ver 1.4.1: Detailed description of three requirements / Whole group / Nov. 15
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- Ver 1.6: Further development / Minh Quoc / Nov. 16
- Ver 1.7: Open issues / Jovana / Nov. 17
- **Ver 2.0: Final version of phase 2 / Nov. 17**

CONTENT AT A GLANCE

1. Introduction:

1.1. Content and purpose of this document

The idea of a public transportation data software has been made by the city of Tambester. They have been working with Con-Salting Oy, a consulting company, to write the frame story. However, Tambester does not have a concrete specification of the software. So, this document is created for the city of Tambester so that they can publicly ask for funds for this public transportation data software.

What does this document cover? Well, it covers the specification of the public transportation data software. What you will find inside this document are the detailed analyses of the current market situation, PESTE, and stakeholders. There are multiple diagrams and explanations to model the system, and there are charts and timetables for plans. Furthermore, working environment and future development are also discussed in this document.

This document is just the specification, so it only contains what the customers want how this system works and how this system behaves. This contains high-level requirements abstraction, not the lower tier specification such as technical specification - for instance, choosing which database or which programming language, framework for the system.

1.2. Product, scope and environment

1.2.1. Product's information and objectives

The product "Public Transportation Data Software" is a system that collects, analyses, and applies public transportation data of the city of Tambester in order to enhance services and making good decisions in the future.

The data is mainly about what routes, what time the passengers travel, and what kind of tickets are used (child, normal, senior and monthly tickets or single fare). This is the primary source for all the benefits later on.

Traffic planners will use the data to plan future route combinations and time tables. The data is also used to write report of how well used the public transportation is and how much ticket profit it created. Other bureaus outside the traffic bureau, such as the environmental bureau, wants to have data from the software. Environmental bureau wants to know about driven kilometers and customers per bus and bus model to estimate the usage of busses reduced carbon emissions compared to equivalent private car usage.

Passengers can have a glance at the statistics about which times and routes are most full or delayed. Bus maintenance crew will use the statistics to focus their maintenance such as cleaning and repairs.

1.2.2. Scope

The public transportation data software itself connects to a variety of other systems. It needs the supports from existed systems to work properly and efficiently. For instance, it gets the transportation data from different sources such as buses, smart cities, and in the future, the trams. One of the systems which helps collecting those data is the tracking devices. It monitors the positions of public transportation and store them onto the Cloud Services. The software will get the data later on.

Statistical analysis is also connected to our product. There are two main types of data that the stakeholders are interested in: environment and revenue. The other types of data that the system collects are routes information, feedbacks from passengers, bus usage and driven kilometers, etc. The data software will use these data to detect trends, patterns, run simulations, and display other statistics.

The more systems our product connects to, the higher the chances of data leaking. Therefore, we will keep this product within a tolerable scope.

For a brief view of the scope of our product, please check the picture in the next page.

1.2.3. Operational environment

The public transportation data software is created to work on different platforms. These basically include web-based, mobile operational liked Android and iOS, and desktop environments. However, different environments are made for different types of user. End users are able to use the application on their mobiles or desktop browsers, but managers and other bureaus only have desktop version.

The smaller modules of the software are embedded into where it wants to get the data from. For example, the NFC ticket selling machine on a bus will have some parts of the software embedded into, which will effectively enhance the data collecting process.

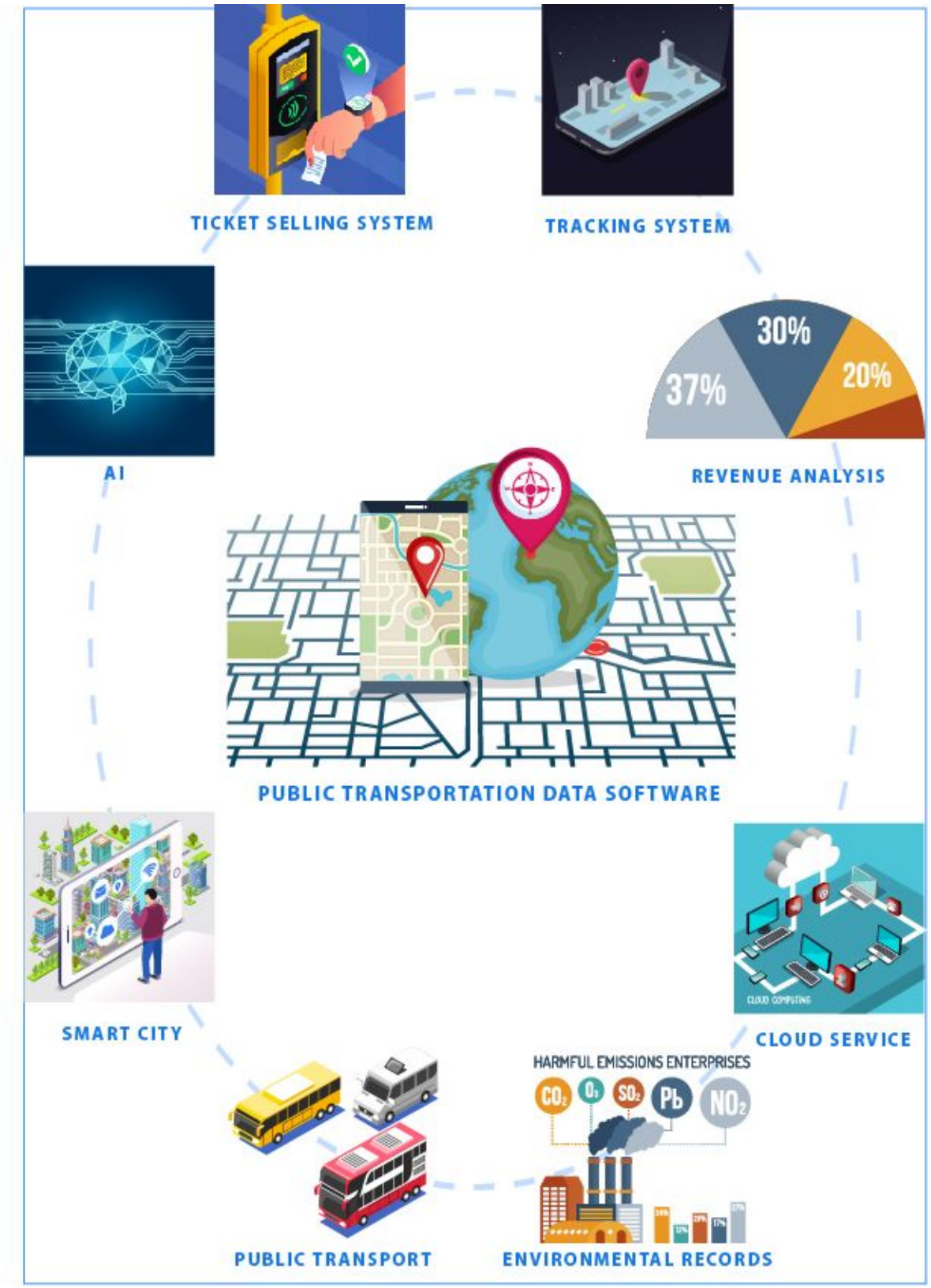


Figure 1.1 *Scope of Public Transportation Data Software*

1.3. Users and purpose of use

Below is the table that analysing different type of users, describing and listing the purpose and some of their status.

Table 1.1 *Users and some purposes of use*

User	Purpose of use	Describing	Training required	Frequency of use	Using environment
Traffic planners	Route planning	Traffic planner will get the data from many sources. They can use that data to run simulation and calculation to determine new possible route and location of new tram that are maximizing the convenient of passenger and cost of building tram, and revenue from bus ticket, etc.	Traffic planner need time and instruction from IT department to get acquaintance with the system	Traffic planners use it everyday and this is one of their main tools.	Traffic planners mainly use the system on the computer.
City council	Getting data and monthly reports	City council wants to have regular reports for their monthly meetings to see how well used the public transportation is and how much ticket revenue. City council also needs the combined data and per route so that they can evaluate the benefits of building public transportation to specific areas	IT department of City Council can get used to the system with the instruction from the developers or the user guide.	City council will get the reports and data in their monthly meetings.	City council will use the system on their computers to print reports
Traffic bureau	Receiving data	Traffic bureau will get the data about the number of bus used in the city, the number of people used bus for traveling, researching like at what hour in a day the bus is most used, how income, age and other factors affect to the usage of public transportation, etc.	IT department in traffic bureau needs little time in the beginning with the instruction to get familiar to the system.	Traffic bureau can get the data weekly or monthly depending on their intention.	IT department of traffic bureau will use the system on the computer.
Environmental bureau	Receiving data	Environmental bureau wants to have data about driven kilometers and customers per bus and bus models to calculate how much the usage of busses reduced carbon emissions compared to equivalent private car	IT department in environmental bureau needs little time in the beginning with the instruction to get	Environmental bureau can get the data weekly or monthly depends on their intention.	IT department of environmental bureau will use the system on the computer.

		usage.	familiar to the system.		
Passengers	Checking statistics	Passengers will use the system with separated interface for checking statistics about which times and routes are most full or delayed.	The interface for passengers will give a well navigation. So, no need for any training to the passengers. The system has the guide part for passengers in case they need.	The system is expected to be used by the passengers almost every time they tend to use the bus so it depends on the frequency of buses usage of each passenger.	Passengers will access to the system mainly by their mobile phone, which mostly run on Android and iOS, and might also use the browsers like Chrome, Safari, Firefox, etc.
Bus maintenance crew	Checking statistics	Bus maintenance crew use the statistics of bus usage and driven kilometers to help their maintenance like cleaning and repairing.	Bus maintenance crew need time to get used to the system.	Bus maintenance crew will use the system regularly when they check and clean the bus and also when the bus accidentally stop working.	Bus maintenance crew will use the system mainly on their mobile phone and maybe laptop and desktop.

The administrators of the system is the people from the IT department from Tambester City. They manage the system, frequently check, get the reports about faulty and fix it. The administrators will guarantee that the system works properly.

Since the main purpose when making the system is helping the city in building new tram network, the most important user of this system is the traffic planners. When building the system, it is important to consider the opinion from traffic planner teams. The system must be easy-to-use for the traffic planners, also satisfy the analysis and simulation requirements, constraint about performance and stability, etc.

The data transportation system is a multiuser system that allows many people from different groups to work on the system at the same time. That requires the system can tolerate some specific amount of accessing simultaneously and the administrators reasonably distribute resources over the users.

The user interface for bus travellers will be presented in Finnish, Swedish and English. In the future, if there are other languages found to be used more frequently, the interface for passengers can be updated with those languages.

1.4. Terms, definitions and abbreviations

- AI: Artificial Intelligence
- CEO: Chief Executive Officer
- CTO: Chief Technology Officer
- Cyber: related to network and online platforms
- End-user: person or organization that actually uses a product, as opposed to the person or organization that authorizes, orders, procures, or pays for it. [1]
- GPS: Global Positioning System
- IoT: Internet of Things
- NFC: stands for "Near Field Communication" and, as the name implies, it enables short-range communication between compatible devices. [2]
- PESTE-analysis: analysis based on five categories: Politics, Economics, Social, Technology, and Environment.
- Scrum: a framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value. [3]
- UI/UX: User Interface/User Experience

2. Requirements gathering plan

2.1. Current situation

2.1.1. Current situation and planning

At the moment, public transportation data in the city of Tambester come from existing public transportations, such as buses or trains. These data may be collected from sold ticket and locating devices, which indicate the time and movement of the bus/train. The system is planned to continue to collect more data from current public transportations, and in the future, from tram too. Moreover, with the IoT(Internet of Things), data are also expected to be collected from smart city.

The city of Tambester need the data from the aforementioned sources so that when the tram is added to the system, they will have enough information to make good decisions. As mentioned in the Introduction, the city of Tambester has been working with a consulting company Con-Salting Oy, who then provides solutions for the UI and UX of the system. However, Con-Salting Oy is not a software engineering professionals, so Tambester need an implementation of a public transportation data software to fulfill their plans.

2.1.2. The usage of data and some drawbacks

The data is currently been used to real-time track public transportations' location and detect crowded areas. This is then used to suggest most reasonable routes based on travelling time and distance. The data is also utilized to study the habit of people, hopefully to reasonably allocate routes and stops or to enhance the services. The tracking system is working almost accurately with the error within tolerable range; however, there are some complains about the timing and the services provided by the city of Tambester. Therefore, Tambester is desperate for more data.

The data are at some point available, but there are some "noise" in the dataset. That is, the data that contribute nothing to the city of Tambester's goals. These data may be the results of faulty data collection instruments, human or machine data entry error, data transmission errors, or the algorithm itself missing some patterns. For instance, a problem with GPS device on a bus might lead to inaccurate travel path, and thus affects other factors such as time calculation and fuel consumption record.

2.2. Current documentation and similar products

2.2.1. Current documentation

Currently, there is only one documentation about the system, which is the Frame Story gathered by Con-Salting Oy. This Frame Story draws a brief picture about the city of Tambester at the moment, including their needs, plans and somes restrictions. Moreover, based on the documentation, we have listed some useful information about this product in the previous section. Here is a brief recall of what we have written about the product:

- It collects and displays data from public transportation.
- Most important data: routes, times, and ticket types and sales.
- It is used to quickly plan route combinations and timetables.
- In the future, AI might be embedded into the system.
- It will record regularly some sorts of profit and statistics.
- It will provide environmental-related data.
- It has different interfaces for different user groups.
- UI/UX solutions come from Con-Salting Oy.
- Using data to run simulations.
- It connects to some other systems.

Should you need more detailed information, see *"1.2. Product, scope, and environment"* on page 3.

2.2.2. Similar products

Traffic softwares are available everywhere surrounding us. It is not difficult to find out a traffic applications, which collect data and help with routing, on Google Play Store or Apple Store. There are lots of them, but the biggest competitors are (and particularly in Finland):

- Google Map
- Apple Map
- Nysse Mobile
- Data transportation system from other cities.

2.3. PESTE

Table 2.1 *PESTE analysis*

Political	- Size of government budgets - Competition regulation - Level of government subsidies - Vehicle quota - New tax policies - Changes in roads made by government - Laws about privacy so that tracking data is allowed
Economic	- Propensity of people to spend and their income - Economic growth patterns - Changes in fuel prices - Costs of tool to protect data - Labour costs (for developers, managers,...) - Ticket prices
Social	- Immigration and emigration rates - Lifestyles - Internationalization - Attitudes towards leisure time - Education level - Age distribution - Public transportation's stops
Technological	- Access to new technology - Cybercrime - Basic infrastructure level - Internet infrastructure and penetration - Database size - Technology level in country industrial - Unhelpful data
Environmental	- Climate change affects the transportation usage - Air pollution comes from vehicles - Power consumption of data centres - Rapid development of environmentally-friendly vehicles

2.4. Stakeholder analysis

Table 2.2 *Stakeholder analysis*

Stakeholder class	Stakeholder	Role	Required participation	Impact level (Project on stakeholder)	Areas of influence
Financiers	Banks	Sponsor	Steering group meetings, planning	Low	Goals
	Government	Sponsor, controlling taxes		High	Taxes. business restrictions, goals, regulations
	Personal investors	Financier		Medium	Risks, funding, goals
	Public foundations	Financier		Medium	Risks, funding, goals
Organizations	City councils	Enacting laws	Planning, requirement	High	Goals, administration
	Con-salting Oy	UI/UX experts + consultants	Planning, requirement, design	Medium	Interface, consultancy
	Public transportation companies	Vehicle providers	Testing, operation	Medium	Goals
	Telecommunication companies	Connection infrastructure providers	All phases	Medium	Functionality
Developers	Software developers	Software builders, coders	Building the project, all phases	High	Functionality
	Testers	Testing functionalities	Testing	Medium	Functionality
	Maintainers	Fixing bugs, regular maintainers	Maintenance	Medium	Usability, functionality
	Network engineers	Network maintainers and administrators	Prototyping, development, operation, maintenance	Medium	Functionality
	UI/UX designers	Graphic designer	Design, maintenance	Medium	Functionality, interface
	AI engineers (future)	Building, testing, and maintaining AI models	Building the project in the future,all phases	Medium	Functionality
	Cyber security engineers	Planning, implementing, managing, monitoring	Development, operation	High	Security

		online security solutions			
	Scrum team	Monitoring scrum processes and scrum meetings	All phases	Medium	Work distribution
Analysts	Data scientists	Data analysts, trends detector, implement future predictor	Operation	Medium	Analytic, data
	Financial analysts	Data analysts, trends detector, implement future predictor		Medium	Analytic, data
Workers	Drivers	Transportation drivers, data contributors	Operation	Low	Goals
	Sales	Marketeer, product advertising	Deployment, operation	Medium	Finance, business restrictions
	Human Resource Department	Recruiting and placing workers	Planning	Low	Human resource
	Bus maintenance crew	Bus maintainers, cleaners	Operation	High	Services
Customers	End-users	Users	Testing, operation	High	Revenue
	Traffic bureau			High	Revenue, traffic solutions
	Environmental bureau			Medium	Revenue
	Traffic planners			High	Revenue
Legal-related	Lawyers	Legal proceedings representatives, advisors	Planning	Medium	Legals, intellectual property
	Lawmakers	Drawing up legal documents		Medium	Policies, legals
Managers	Project managers	Monitoring, documenting, planning, budgeting,... the project	All phases	High	Administration, technical restrictions
	CEO	Developing business strategies, overseeing all operations and business activities	Planning	High	Administration
	Financial managers	Reviewing financial reports, monitoring accounts, analysing market	Planning, operation	Medium	Finance, business restrictions, administration

	CTO	Outlining vision, implementing technical strategies, controlling technical resources	Planning, deployment	High	Administration, technical restrictions
Medias	Newspapers	Public opinion controllers, spreading news	Marketing, in the end of project	Medium	Public opinion
	Broadcasting channels				
	Social networks				
Community	Similar products' owners	Competitors	Planning, requirement, at the beginning	High	Market, revenue, intellectual property
	Ticket buyers (not end-user)	Data contributor	Testing, operation	Low	Data
	Private car owners	Data contributor	Testing, operation	Low	Data

Figure 2.1 *Stakeholder analysis*

2.5. Preliminary requirements and their categorization

Priority: - ***1**: Most important*

- ***2**: Important*

- ***3**: Least important*

Type: - ***F**: Functional*

- ***NF**: Non-functional*

- ***R**: Restriction*

***Table 2.3** Preliminary requirement*

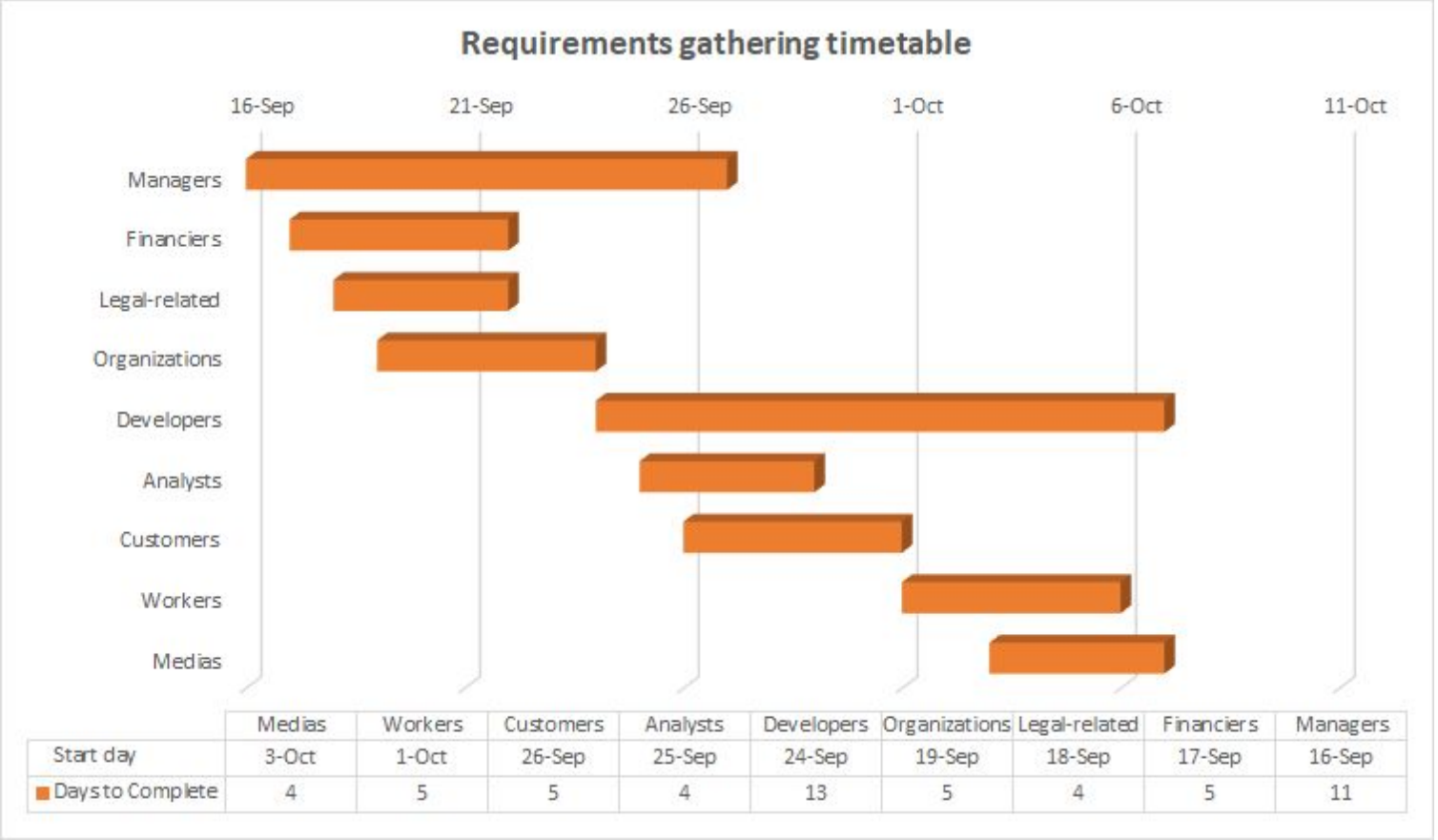
ID	Priority	Source	Type	Requirement description
1	3	Frame story	NF	All data is public
2	1		R	System has connection to ticket system and tracking system in the vehicles
3	1		F	System can collect data about routes, times, and types of tickets
4	2		F	System collects the usage and ticket selling situation of public transportation
5	3		F	System collects the carbon emissions data from busses
6	2		F	System collects data about driven kilometers, customers per bus, and bus models
7	1		F	System can update, add, and delete routes when planning route

8	1		F	There is a simulator to approximate and show the results of new route combinations
9	2		NF	Route information should be returned to user within 3 seconds
10	1		NF	The simulator can run on low-setting computers, e.g. computers with Intel i3
11	2		R	AI can be integrated into system in future without crashing it
12	3		F	System can generate reports about the usage of transportation and ticket revenue on the first day of new months
13	3		F	The revenue data should be reported in total sum and in per route form
14	2		R	System must have a separate interface for passengers
15	1		F	User's interface should contain information about times and routes that are most full or delayed
16	3	Bus passengers	F	The system can search for public transportation's information
17	2		F	Users can see the real-time position of buses and approximated arrival time
18	2		F	The system should let users to buy online ticket and store it on their device
19	1		NF	The route searching function should return values with 3 seconds during rush hours

20	2		F	Users can save map and timetables to use when offline
21	1		R	User's interface should at least has English and Finnish
22	1	Traffic planner	NF	The optimization algorithm can be chosen by traffic planner
23	2		F	The system can generate statistics report about existing routes to give traffic planner an overall view
24	1		F	The simulation process must be saved periodically when running in case of system crashing or power cut
25	3		NF	The stimulation result must be display in text form liked report and also a map including new route highlighted
26	2		F	The work of one planner can be shared to other planners with selected right
27	2		F	System provides a simple interface of the route planning system with basic information that traffic planner can see stimulation progress, edit constraints, criteria for new route in case they are at home, or cannot access to computer in the office
28	1		F	The system must show a warning before running stimulation when the input data is too large compare to computation power of the system
29	2		F	The system can update the map of Tambester city and notify where, what and when are changed
30	3		F	All traffic planner will get a message within 24 hours by email from administrators when the system update
31	2	IT-department	R	There is only one database [4]

32	1		NF	The database can contain up to 100.000 users information
33	1		NF	The cloud service should operate stably, i.e. it is allowed to suspend once a month
34	2		R	Only people from IT-department having enough permission can access the database directly
35	1	External systems	NF	Connection to other systems should be stable 24/7
36	1		NF	Connection's bandwidth should be maintained at least 40Mbps
37	2		NF	System can receive data from external sources within the range of the city
38	1		NF	The system should not collapse if too many sources sending data at the same time
39	2		F	The system should use a secured channel for transfering data so that it will not conflict other with existing channels.
40	1		NF	Data sent to the system must be encrypted to ensure the security
41	1	Legal-related	R	All data must not be sold to third-party for any reason
42	2	Other	R	The system can work on different platforms (Mobile, PC, Web)

2.6 Methods and timetable for requirements gathering



	Medias	Workers	Customers	Analysts	Developers	Organizations	Legal-related	Financiers	Managers
Start day	3-Oct	1-Oct	26-Sep	25-Sep	24-Sep	19-Sep	18-Sep	17-Sep	16-Sep
Days to Complete	4	5	5	4	13	5	4	5	11

Figure 2.2 *Gantt chart for requirements gathering plan*

***Table 2.4** Requirement gathering methods and person responsible*

Stakeholder	Method	Person responsible
Managers	Brainstorming, Meetings	Manager of all company departments
Financiers	Brainstorming, Meetings	Manager and finance department
Legal-related	Meetings	Legal department
Organizations	Meetings	Administrative department
Developers	Brainstorming, Meetings, use cases, prototyping	Managers
Analysts	Facilitated sessions	Managers
Customers	Use Cases, Group interviews and Questionnaires, Prototyping	IT-department, Finance department, Business analysts
Workers	Group interviews, Questionnaires	Business analysts, IT-department
Medias	Meetings	Public relations

3. Requirements and modeling the system

3.1. Modeling (diagrams)

3.1.1. Use case diagram(s)

The Use case diagram represents the scope and extent of the public transportation data software. Each actor has one role, i.e. one type of user. From the diagram, you can see what one can do with the application as well as the relationship between functionalities and users. For instance, a traffic planner can use the software to plan the route, or the traffic bureau can use the software to get reports that they want. Moreover, "extend" arrow denotes what functionalities the user can further use during a use case. On the other hand, "include" arrow denotes what is required for a use case.

Below you can find the detailed description about two most important use cases:

USE CASE: *Planning route*

- **Pre-condition**: There is public transport and there are databases that include all the route information and they can be changed. Each route has its own number and specific information in the system that can be accessed by logging a traffic planner through their interface**.**
- **Description:** Traffic Planner logs into the system with its own username and password. It then finds a route in the database that it wants to change or delete. The other option is to add a new route with its own new specific number.
- **End result**: The route is displayed on the traffic planner. It can be upgraded or deleted or a new route that does not exist can be added by it. To do this, the planner must finally confirm that he agrees to the change in the database.
- **Priority:** Critical
- **Exception 1:** The route does not exist in the database.
- **Exception 2:** There are several same routes in the system.
- **Exception 3:** To add a route with the same information as one that already exists
- **Exception 4:** The planner's computer is not powerful and they can't see the route specific information quickly
- **Exception 5 :** The traffic planner's username doesn't exist or the password is wrong.

USE CASE: *Check public transportation usage from report*

- **Pre-condition:** There are public transportation currently in operation and being monitored to get data. At least one of the reports of the public transportation usage exists in the system and can be accessed from the city council's interface.
- **Description:** Staff from city council logs in to their interface. System checks if the account has enough permission to access the reports. The staff choose to view the report he/she wants from the report list.
- **End result:** The report is displayed to the staff. The staff may then download, send the report, or analyze it with tools, but he/she must agree with the terms and conditions in advance.
- **Priority:** Important
- **Exception 1:** The staff's account is locked or his/her permission is not enough.
- **Exception 2:** The staff can view the report but does not have enough permission to send or download it.
- **Exception 3:** The report is shown available to the staff, but it is removed from the database before the staff chooses to view it.
- **Exception 4:** The staff's computer does not have any compatible application to view the report.

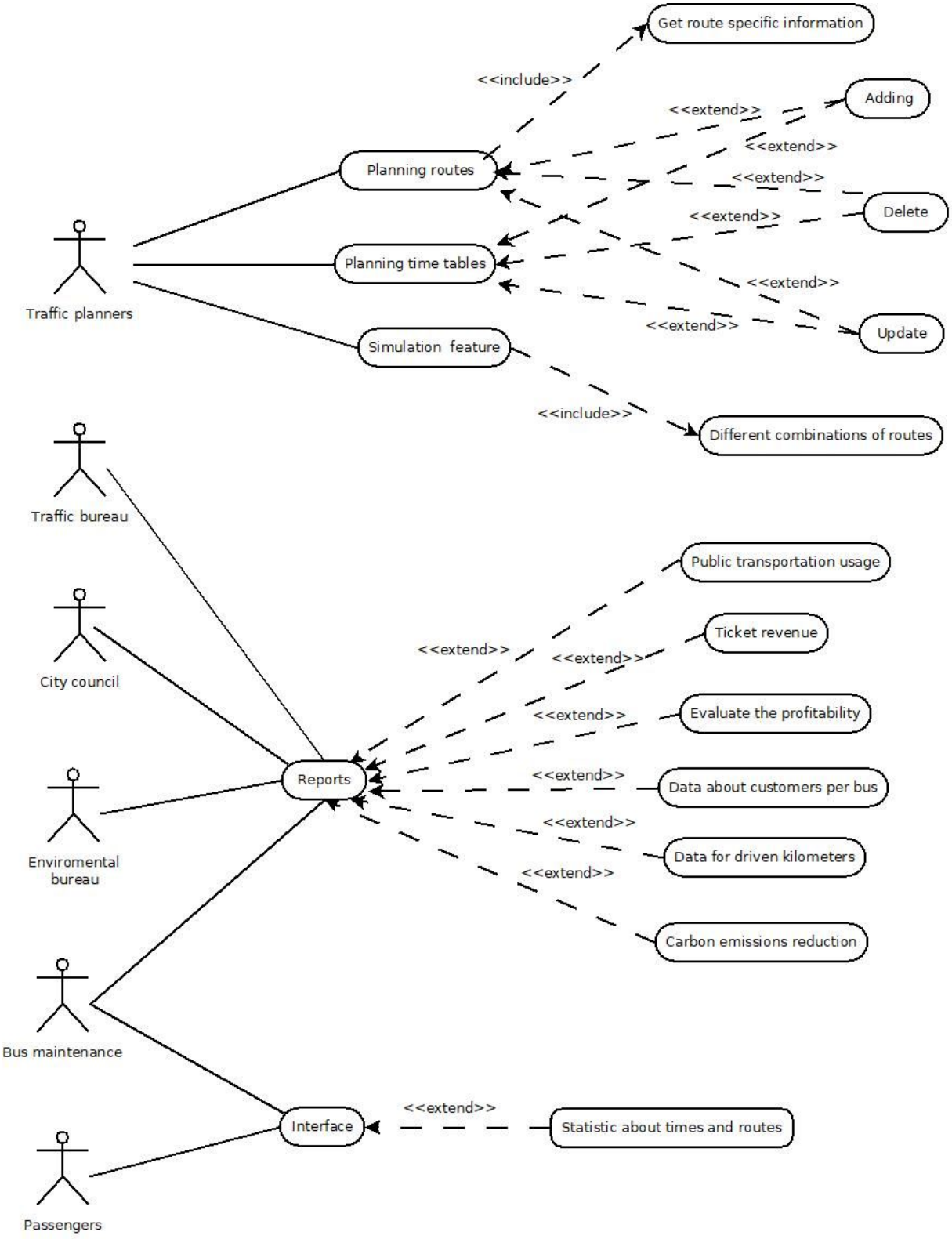


Figure 3.1 *Use case diagram*

3.1.2. Entity/Concept diagram

This diagram includes all entities from the public transportation data software as well as their relationships and multiplicities. Entities are basically what participate in the software. Relationships denote the connection between entities. Multiplicities constraint the amount of each entity in relationship with others. For instance, between class "Organizations" and "Report" in the diagram below, a report can belong to 0 or 1 organization, while an organization can have zero to many reports.

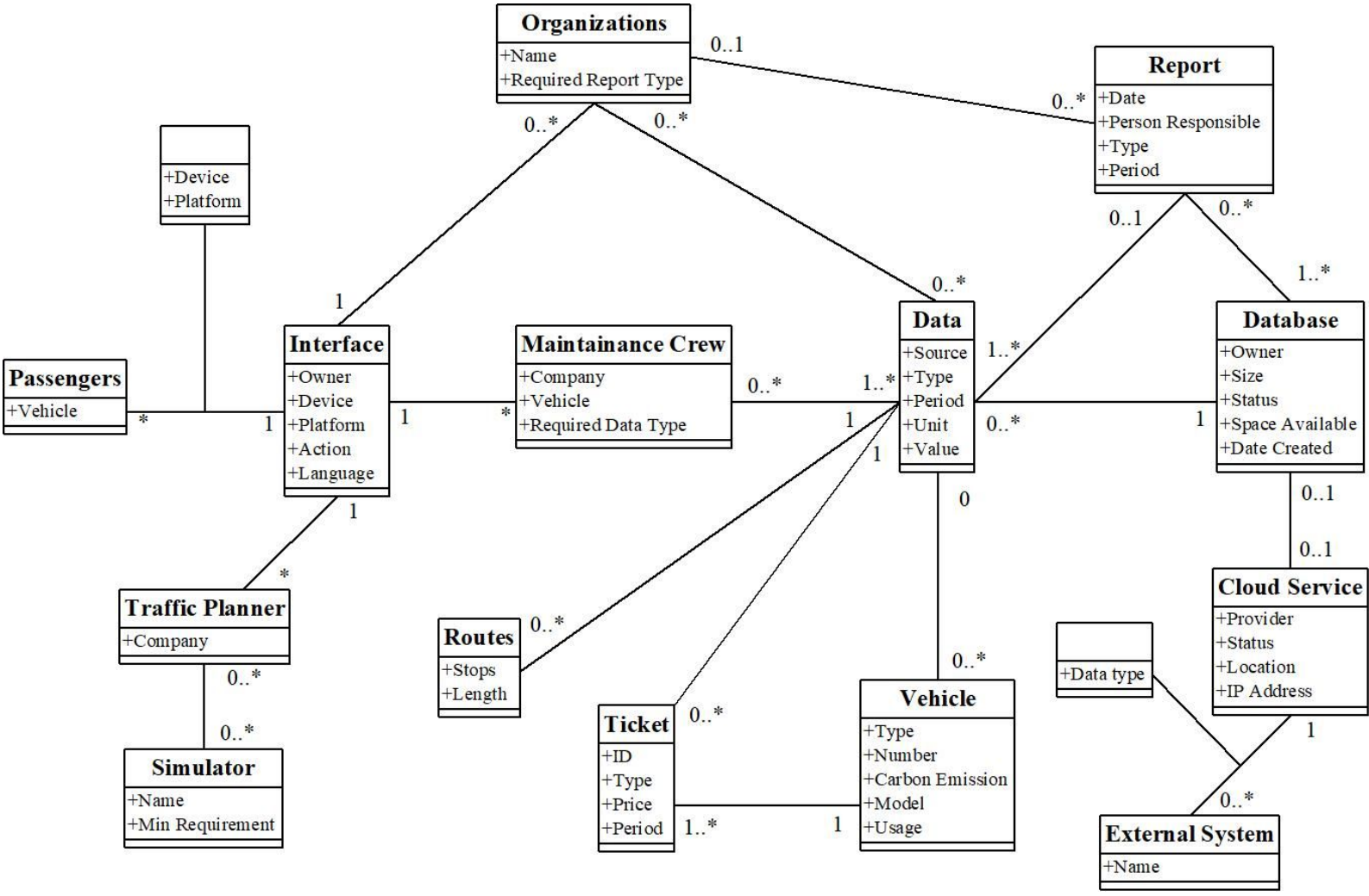


Figure 3.2 *Class diagram*

3.1.3 Navigation diagrams

Navigation diagrams show you the process you might experience when using the application. They describe step-by-step how the UI will show, i.e. the flow of the software. Since traffic bureau wants to have a separate interface for bus passengers, we make two different navigation diagrams.

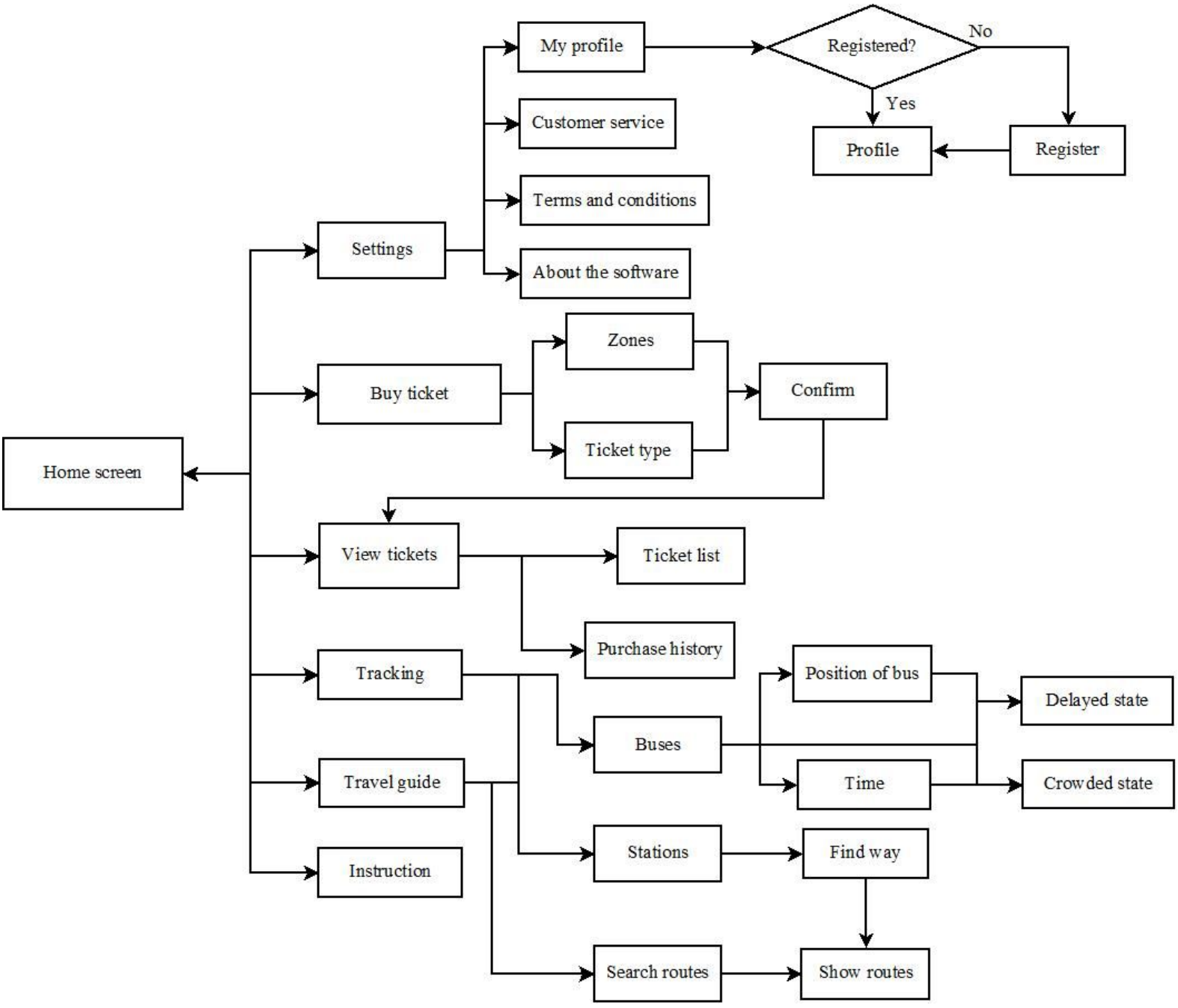


Figure 3.3 *Bus passenger interface navigation diagram*

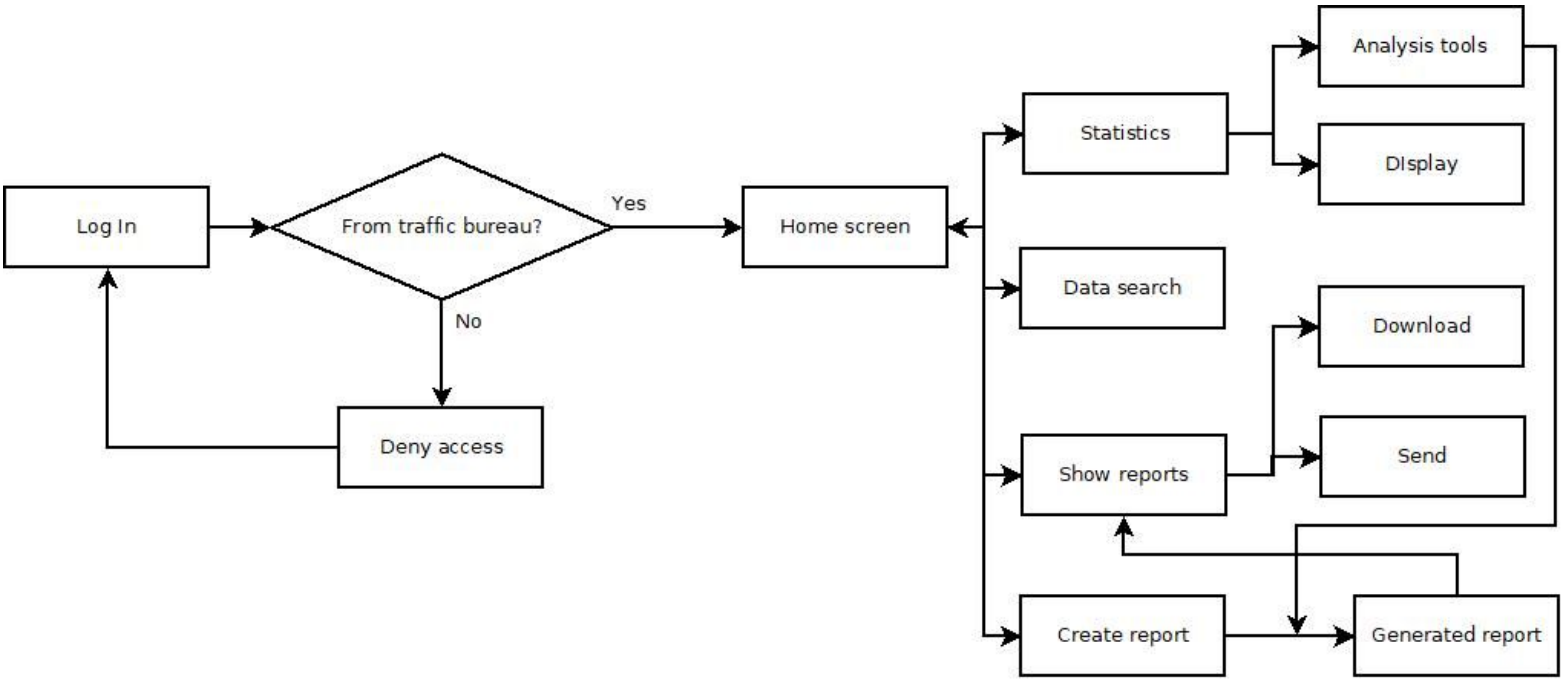


Figure 3.4 *Traffic bureau interface navigation diagram*

3.2. User interface

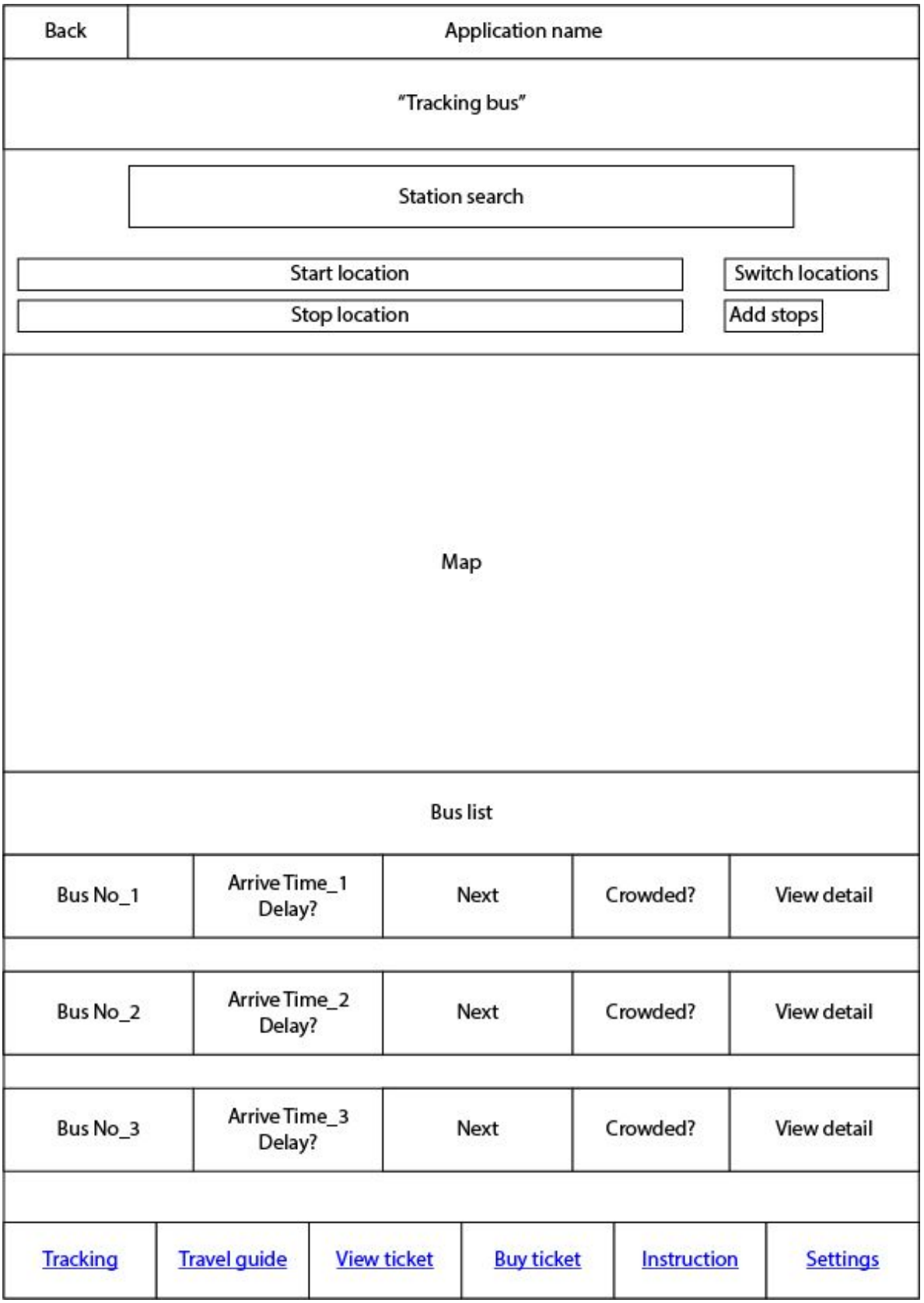


Figure 3.5 *Tracking interface for bus passengers (Mobile/Tablet)*

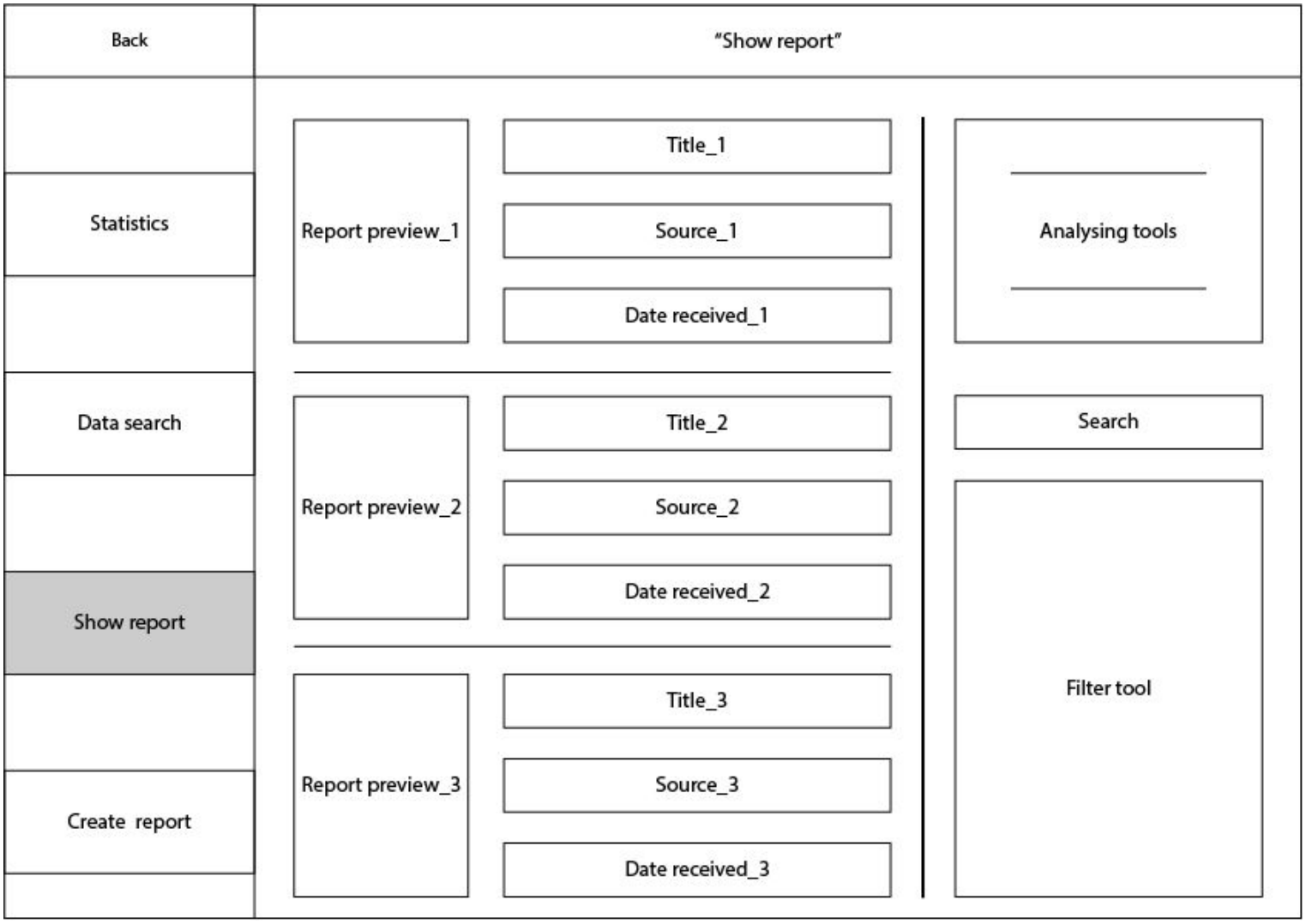


Figure 3.6 *Report view interface for organizations (Computer)*

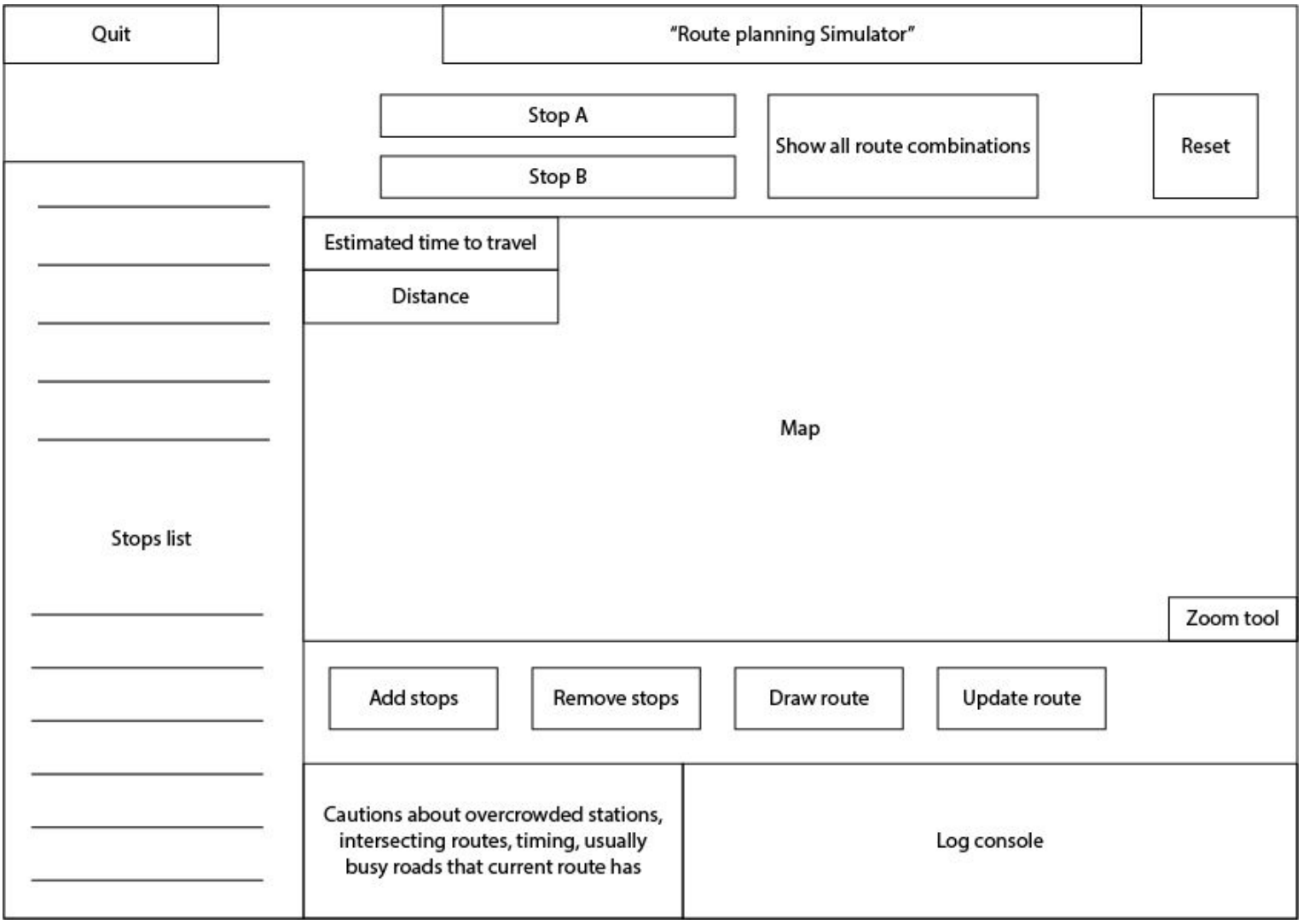


Figure 3.7 *Simulator interface for traffic planner (computer)*

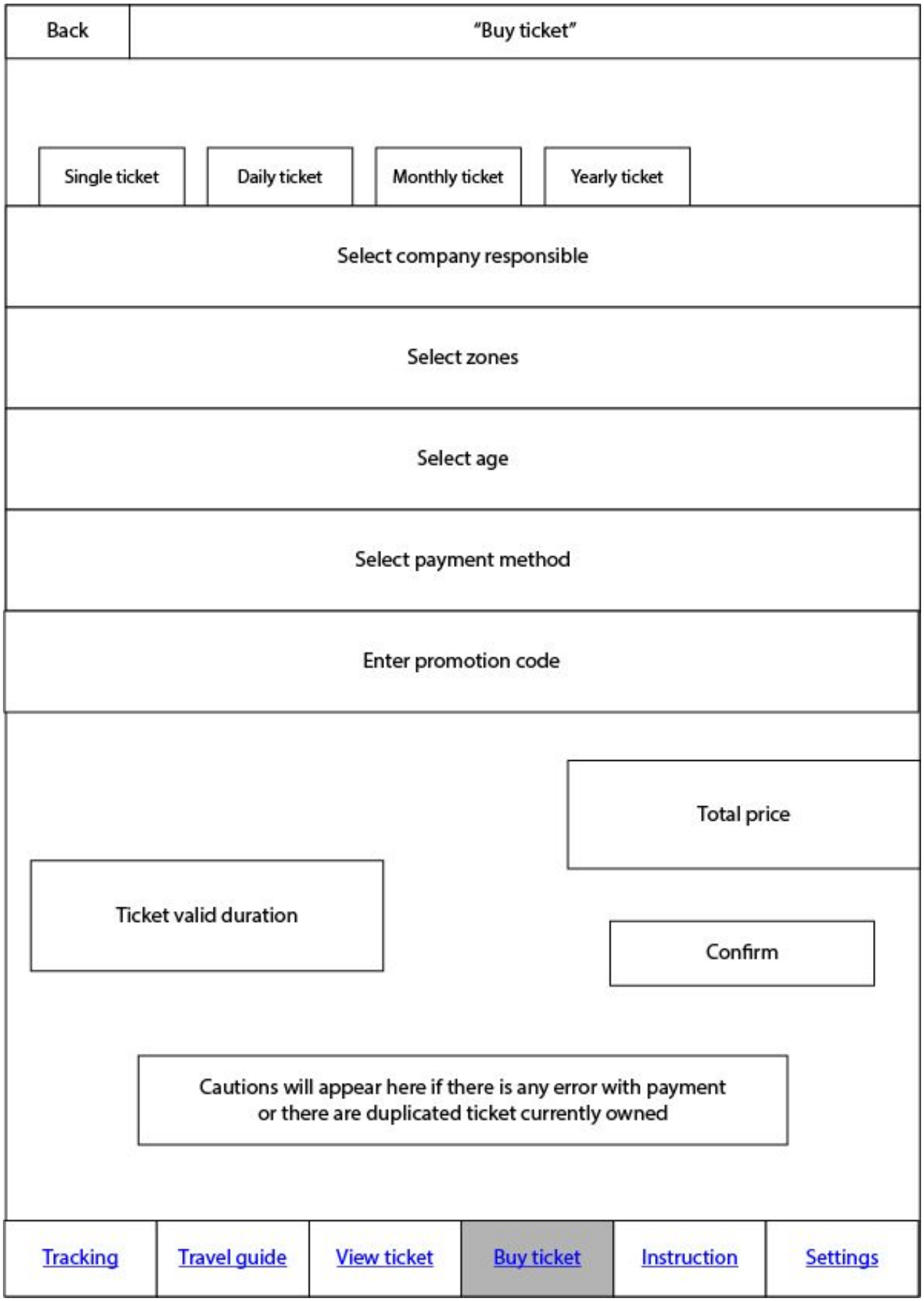


Figure 3.8 *Buying bus ticket interface for bus passengers (Mobile/Tablet)*

3.3. Requirements

After the requirement gathering, we have collected more requirement from different sources. We added those to the ***Table 2.3*** on page 17, appending to the existed requirement from the Frame Story. The new requirements start from ID **16** until the end.

3.3.1. Example functional requirement *"Users can see the real-time position of buses and approximated arrival time" (ID 17)*

Bus passengers use their mobile and select the "Tracking" tab. They can either selection a station or search for a route from location A to location B. The system will display the buses available to the selected station or the nearest starting station. At the same time on the map, there will be the real-time locations of the buses coming to the station as well as the estimated time the buses will arrive.

3.3.2. Example non-functional requirement *"System can receive data from external sources within the range of the city" (ID 37)*

Every external source of data, such as buses, smart cities, or trams, can send data to the system if it is within the city's area. The data should be transferred to the nearest receiving station, and then later to the data center. Even the buses traveling at the edge of the city should be monitored continuously to prevent the loss of data. Therefore, this requirement requires either to build more receiving stations or to enhance the range of connection between external systems and the existing receiving stations.

3.3.3. Example restrictions requirement *"The system can work on different platform (Mobile, PC, Web)" (ID 42)*

When the system first launches, the specific interfaces of the system for bus passengers must work stable on Android, from Android Pie and on iOS operation, from iOS 13. It is also compatible with Google Chrome, Firefox and Safari.

The system also provides specific interfaces for traffic planner's mobile with the same environment above. On the other hand, the system can operate on Windows 10 on the computers at office and the desktops of employees.

Finally, the data transportation system provides web platform for traffic bureau, environmental bureau and City council to access to get the information about ticket sales and other statistics.

3.4. Environment

3.4.1. Other systems and specialties

The public transportation data software has connections to multiple external systems to aggregate data. You can find the external systems in the ***Figure 1.1*** on page 6. Our system will provide data in the form of report to bureaus who have interest in our data, such as environmental bureau, traffic bureau, and city council.

The requirements about external systems can be found from ***Table 2.3*** on page 17 on the rows having "External systems" as Source.

3.4.2. Required connections and communication and other environmental requirements

The requirements about external systems can be found from ***Table 2.3*** on page 17 on the rows having "External systems" as Source.

3.5. Further development

One of the most important improvement, to catch up with the rapid development of the city, system will update to more powerful computers to run simulation in less time and AI system will be added to the system to enhance route planning performance.

On the other hand, for improving passenger satisfaction, the passengers will get route information more quickly and interface for passengers will be modified base on their feedback.

In the future, the database will be expanded in capacity and access speed from Cloud provider or change to other providers base on considering pricing.

The data source will include data get from new trams. IT department also work to find way to improve quality of input data such as reduce noise, and made the data in proper format.

5G is currently developed and being tested to study its efficiency. With the help of IoT, this new generation of communication will open a bright future for the future technology, such as self-driving car, which requires a significant bandwidth to operate. The data from the public transportation data software can be a useful resource for the development of future technologies.

3.6. Open issues

At the moment of creating this documentation, most of the problems come from time, finance, and technical aspects.

Time and finance usually go together. The requirements found in the ***Table 2.3*** on page 17 are just what we found from the Frame Story and through the requirement

gathering process. In the future, more requirements will appear, and this means more time and money. It is difficult to estimate the accurate amount of time and finance to support the project.

Data collecting has never been an easy procedure. Data, however, will inevitably have noise, which will cause difficulties while analysing. We have not had any specific algorithm to analyse the data, so it might be a difficulty to come up with a new model. Moreover, we need to careful with regulations about user's privacy and data aggregation.

Since this is a new system, we might need to embed software to the existing external systems to establish a connection to our system. Also, the current infrastructure in the city is not adequate to provide a stable connection 24/7.

4. References

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[4]: TIE-02306 2019-01 Introduction to Software Engineering Requirements_example [Moodle internet learning environment] updated at 2019-10-05 [2019-11-15]. Available: https:/Moodle.tuni.fi/ > TIE-02306 2019-01 > Example materials for project work > ItSE_Requirements_example.pdf

5. Appendices